between benign and malignant adrenal masses. Burt and coworkers in fact refer to our 1992 article and acknowledge that chemical-shift MRI might be more effective than the methods they used. They did not, as they state, use the "best currently available MRI scanning techniques" for their 1994 publication.

I hope that Burt and associates and other thoracic and cardiovascular surgeons maintain their interest in the potential impact of MRI on presurgical diagnosis. Well-designed studies on this subject would be of benefit to the surgical and radiologic literature alike.

Donald G. Mitchell, MD
Professor of Radiology
Thomas Jefferson University Hospital
Jefferson Medical College
132 South 10th St.
196 Main Building
Philadelphia, PA 19107

REFERENCES

1. Burt M, Heelan RT, Coit D, et al. Prospective evaluation of unilateral adrenal masses in patients with operable non-small-cell lung cancer: impact of magnetic resonance imaging. J THORAC CARDIOVASC SURG 1994;107:584-9.
2. Kier R, McCarthy S. MR characterization of adrenal masses: field strength and pulse sequence considerations. Radiology 1989;171:671-4.
3. Baker ME, Blinder R, Spritzer C, Leight GS, Herfken RJ, Dunnick NR. MR evaluation of adrenal masses at 1.5 T. AJR Am J Roentgenol 1989;153:307-12.
4. Leroy-Willig A, Courtieu J, Roycayrol JC, Luton JP, Louvel A, Niesenbaum N. In vitro adrenal cortex lesions: characterization by NRM spectroscopy. Magn Reson Imaging 1987;5:339-44.
5. Leroy-Willig A, Bittoun J, Luton JP, et al. In vivo MR spectroscopic imaging of the adrenal glands: distinction between adenomas and carcinomas larger than 15 mm based on lipid content. AJR Am J Roentgenol 1989; 153:771-3.
6. Mitchell DR, Crovello M, Matteucci T, Petersen RO, Miettinen MM. Benign adrenocortical masses: diagnosis with chemical shift MR imaging. Radiology 1992; 185:345-51.
7. Tsushima Y, Ishizaka H, Matsumoto M. Adrenal masses: differentiation with chemical shift, fast low-angle shot MR imaging. Radiology 1993;186:705-9.

12/8/58953

Reply to the Editor:

In response to Dr. Donald G. Mitchell's letter to the Editor, we have the following comments. We thank Dr. Mitchell for his comments and criticisms. Although magnetic resonance imaging (MRI) methods are currently being investigated that possibly could lead to better discrimination of adrenal masses as being benign or metastatic in non-small-cell lung cancer, Dr. Mitchell did not take into account the time it takes for a scientific study to come to full publication. The inception of the study was in February of 1990, and it was approved by our institutional review board in April of 1990. The accrual of the patients reported in our study began in August of 1990 and was completed in October of 1992. An abstract of our study was submitted to The American Association for Thoracic Surgery on November 11, 1993, and the paper was presented at the Seventy-third Annual Meeting in April of 1993. A manuscript was submitted at this meeting. This manuscript was accepted August 20, 1993, and published in the February 1994 issue of THE JOURNAL OF THORACIC AND CARDIOVASCULAR SURGERY. Dr. Mitchell published his technique of chemical shift MRI in the November 1992 issue of *Radiology,* after the completion of our study.

Although newer techniques are being developed in MRI to differentiate benign from malignant adrenal masses, few studies have histologic documentation of all patients reported. Therefore, although our study used the MRI techniques available during the period of the study, the point is still valid that the gold standard for determining the cause of adrenal masses is by cytopathologic or histopathologic study. We too are currently evaluating chemical-shift MRI and other newer MRI techniques, but we remain convinced that histologic examination is the gold standard by which to compare any new MRI technique.

Michael Burt, MD, PhD[a]
Robert Heelan, MD[b]
Department of Surgery[a]
Department of Radiology[b]
Memorial Sloan-Kettering Cancer Center
1275 York Ave.
New York, NY 10021

12/8/60339

Airway complications after lung transplantation: Is there a left-sided predilection?

To the Editor:

We read with interest the article by Griffith and associates[1] that was published in this JOURNAL. They have clearly shown that most complications of airway anastomoses after lung transplantation can be avoided by the refinement of surgical techniques (Table I, J THORAC CARDIOVASC SURG 1994;107:746). Although the etiology of impaired bronchial healing after lung transplantation is multifactorial, bronchial ischemia seems to be the primary cause.[2] In this series all seven patients with severe bronchial stenoses after bilateral lung transplantation had stenotic lesions of the left bronchus (three had bilateral stenoses). These patients were treated with endobronchial stents. Two patients had bronchial stenosis necessitating stenting after single left lung transplantations; by contrast, no bronchial stenoses occurred after single right lung transplantation (Table II, J THORAC CARDIOVASC SURG 1994;107:746). Colt and associates[3] also have reported that all ten patients in whom stenosis developed after double lung transplantation demonstrated abnormalities at the level of the left main bronchial anastomosis (three had bilateral stenoses).

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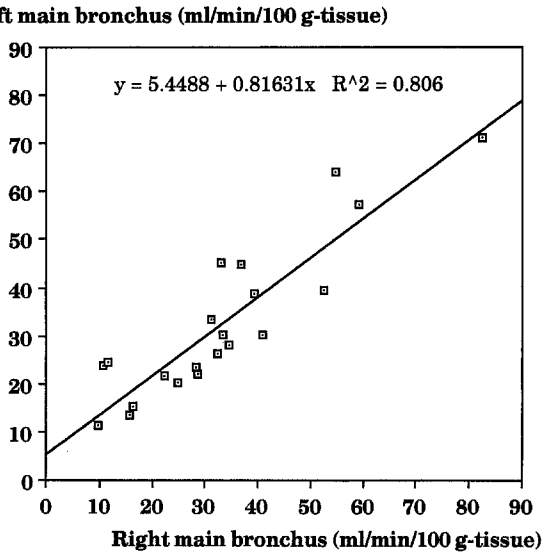

Fig. 1. Bronchial mucosal blood flow at the level of the right *(horizontal axis)* and left *(vertical axis)* main bronchi in patients not undergoing transplantation. They are highly correlated; *left* = 5.4488 + 0.81631 *right*, $R = 0.806$.

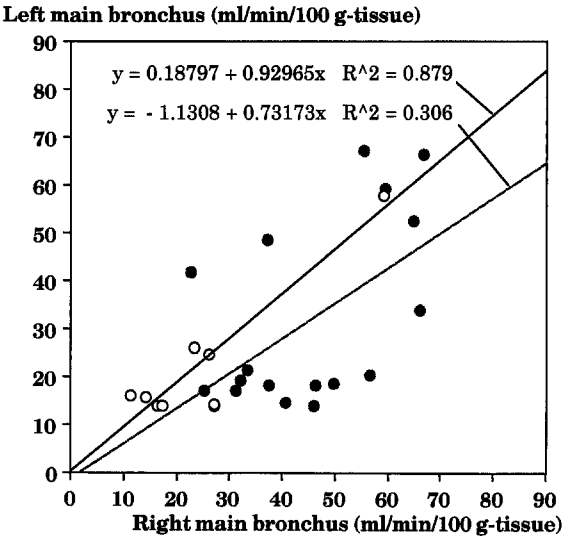

Fig. 2. Bronchial mucosal blood flow at the level of the right *(horizontal axis)* and left *(vertical axis)* main bronchi in heart-lung and bilateral lung transplant recipients. In patients without pneumonia and obliterative bronchiolitis (○), blood flow of both sides is highly correlated; *left* = 0.18797 + 0.92965 *right*, $R = 0.879$, whereas blood flow is significantly reduced in patients during acute rejection. In most patients with pneumonia or obliterative bronchiolitis (●), blood flow is lower in the left bronchi than in the right bronchi, and there is no correlation between the sides; *left* = −1.1308 + 0.73173 *right*, $R = 0.306$.

How can the prevalence of complications in the left main bronchus be explained? It may be related to the longer preservation time of the left lung, which is transplanted after the right lung in cases of bilateral lung transplantation. The blood supply to the donor bronchi, which is a retrograde pulmonary arterial circulation via an intrapulmonary connection between the bronchial arteries and pulmonary arteries, is critical after lung transplantation.[4, 5] Another hypothesis is that such a stenosis may be related to the length of the recipient main bronchus, its anatomic structure, and differences in vascularization between the left and right main bronchi.[6, 7]

We measured bronchial mucosal blood flow using laser Doppler flowmetry (ALF 2100, Advance Co. Ltd., Tokyo, Japan) in 23 patients not undergoing transplantation, 19 patients having heart-lung transplantation, and two patients having sequential double lung transplantation. The time after transplantation ranged from 1 to 55 months. No ischemic airway complications were observed during this period.

The average values of the bronchial mucosal blood flow (mean ± standard deviation) were 40.2 ± 14.6 (main carina), 35.2 ± 17.4 (left main bronchial carina), and 33.3 ± 17.4 ml/min per 100 gm tissue (right main bronchial carina) in patients not undergoing transplantation and 37.6 ± 16.5 (main carina), 29.0 ± 17.8 (left main bronchial carina), and 37.4 ± 17.0 ml/min per 100 gm tissue (right main bronchial carina) in transplant recipients. The bronchial mucosal blood flow was lower in the left bronchus than in the right bronchus by 0.66 ± 7.7 ml/min per 100 gm tissue in patients not undergoing transplantation (Fig. 1) and by 9.5 ± 14.7 ml/min per 100 gm tissue in transplant recipients (Fig. 2). The differences were greatest in transplant recipients who experienced complications such as pneumonia or obliterative bronchiolitis. In three of seven transplant recipients with pneumonia and in four of eleven transplant recipients with obliterative bronchiolitis, the bronchial mucosal blood flow was lower in the left bronchus than in the right bronchus by 15.4 ml/min per 100 gm tissue and more (a 2 standard deviation difference existed in the bronchial mucosal blood flows between the right and left main bronchi in patients not undergoing transplantation) (Fig. 2).

Although the tracheal anastomoses that were performed in patients who underwent heart-lung transplantations may have been supplied via collaterals from the coronary arteries, it is interesting that the bronchial mucosal blood flow of the left main bronchus tended to be lower than that of the right main bronchus in transplant recipients with pneumonia and obliterative bronchiolitis. This lower bronchial mucosal blood flow at the left main bronchus might have been related to the prevalence of abnormal bronchial healing associated with the left bronchus in postoperative lung transplant recipients with pneumonia or obliterative bronchiolitis, whose airway

anastomoses were performed without collateral flow from the coronary arteries.

Motoshi Takao, MD[a]
Syoji Namikawa, MD[a]
Hiroshi Yuasa, MD[a]
Isao Yada, MD[a]
Minoru Kusagawa, MD[a]
Tim Higenbottam, FRCP[b]
John Wallwork, FRCS[c]
Department of Thoracic and Cardiovascular Surgery
Mie University School of Medicine
Tsu, Japan[a]
Department of Respiratory Physiology[a]
Transplant Unit[b]
Papworth Hospital
Cambridge, United Kingdom

REFERENCES

1. Griffith BP, Magee MJ, Gonzales IF, et al. Anastomotic pitfalls in lung transplantation. J THORAC CARDIOVASC SURG 1994;107:743-54.
2. Mills NL, Boyd AD, Gheranpong C. The significance of bronchial circulation in lung transplantation. J THORAC CARDIOVASC SURG 1970;60:866-78.
3. Colt HC, Janssen JP, Dumon JF, Noirclerc MJ. Endoscopic management of bronchial stenosis after double lung transplantation. Chest 1992;102:10-6.
4. Siegelmann SS, Hagstrom JWC, Koerner SK, Veith FJ. Restoration of bronchial artery circulation after canine lung allotransplantation. J THORAC CARDIOVASC SURG 1977;73:792-5.
5. Balie EM, Minshall D, Dodek PM, Paré PD. Blood flow to the trachea and bronchi: the pulmonary contribution. J Appl Physiol 1994;76:2063-9.
6. Pinsker KL, Koerner SK, Kamholz SL, Hargstrom JWC, Veith FJ. Effect of donor bronchial length on healing: a canine model to evaluate bronchial anastomotic problems in lung transplantation. J THORAC CARDIOVASC SURG 1979;77:669-73.
7. Schreinemarkers HH, Weder W, Miyoshi S, et al. Direct revascularization of bronchial arteries for lung transplantation: an anatomic study. Ann Thorac Surg 1990;49:44-54.

12/8/60674

Reply to the Editor:

The suggestion by Dr. Takao and his group that the bronchial mucosal blood flow is reduced in the left main-stem bronchus relative to the right is fascinating and a significant contribution. Since the publication of our article, titled "Anastomotic Pitfalls in Lung Transplantation," we have accrued additional patients from whom to draw conclusions.

A total of 133 patients have undergone single (SLT) or double (DLT) lung transplantation (61 SLT, 72 DLT) and have survived 1 to 50 months. Of these, 15 patients (6 SLT, 9 DLT; 11%) have had significant bronchial anastomotic complications. The method of lung transplantation and suture of or wrapping of anastomoses were not significant risk factors. Patients underwent 41 procedures (range one to nine per patient) involving insertion of 23 silicone rubber stents (range one to five per patient). Sixteen of 23 stents required adjustment because of distal migration and obstruction of the upper lobe. Among DLT recipients, left-sided problems were significantly more common than right (7 versus 2; $p = 0.0117$); two patients had bilateral problems. Strictures in five patients were débrided with the neodymium–yttrium-aluminum-garnet laser on 12 occasions. Stents placed in four patients who died were functioning well at the time of death. Among the 11 survivors, three patients had temporary stents (6 to 15 days); two are well (7 months and 2 years) and one has a stable 40% stenosis. Five patients received long-term stents (160 to 507 days); four are well (4 to 10 months) and one required repeat stenting at 3 months. Three patients were managed with laser débridement alone. Five patients were discharged after transplantation only after stenting for symptomatic relief.[1]

On the basis of these data, it would appear that the left main-stem bronchial anastomosis is at greater risk of abnormal healing, and Takao's finding of a reduced blood flow may indeed have significance. Because all bronchi are trimmed to within 5 to 10 mm of the upper lobe branch, it is not likely that length of donor bronchus is the cause for the higher prevalence on the left for stenosis or dehiscence. It would be of additional interest if the group at Papworth Hospital could perform these studies on bronchial mucosal blood flow during the operation as opposed to later in the course, when effects of reduced blood flow may be more significant. It would be important if revascularization of bronchial arteries could be shown to increase bronchial mucosal blood flow to near normal. It would also be of interest to know what impact the now rarely performed omental or pericardial fat wrap might have on blood flow. This group is to be congratulated for their pioneering efforts in this area, and we look forward to limiting the risk of bronchial anastomotic pitfalls based on surgical maneuvers backed up by objective data such as bronchial mucosal blood flow.

Bartley P. Griffith, MD
Robert J. Keenan, MD
Division of Cardiothoracic Surgery
C700 PUH, UMPC
200 Lothrop St.
Pittsburgh, PA 15213-2582

REFERENCE

1. Keenan RJ, Landreneau RJ, Ferson PF, Hardesty RL, Griffith BP. Endoscopic management of airway complications after lung transplantation. Chest 1993;104:2:129S.

12/8/61889

Bidirectional inferior vena cava–pulmonary artery shunt

To the Editor:

In the May 1994 issue of this JOURNAL (1994;107:1367) I read a letter to the Editor written by Luisi, Murzi, Bernabei, Vanini, and Biagini concerning bidirectional